US009433040B2

(12) United States Patent

Schubert et al.

(10) **Patent No.: US 9,433,040 B2**

(45) **Date of Patent: Aug. 30, 2016**

(54) **LIGHT-EMITTING METAL-OXIDE-SEMICONDUCTOR DEVICES AND ASSOCIATED SYSTEMS, DEVICES, AND METHODS**

(71) Applicant: **Micron Technology, Inc.**, Boise, ID (US)

(72) Inventors: **Martin F. Schubert**, Boise, ID (US); **Vladimir Odnoblyudov**, Eagle, ID (US)

(73) Assignee: **Micron Technology, Inc.**, Boise, ID (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 341 days.

(21) Appl. No.: **13/918,655**

(22) Filed: **Jun. 14, 2013**

(65) **Prior Publication Data**

US 2014/0368123 A1 Dec. 18, 2014

(51) **Int. Cl.**

H05B 41/14	(2006.01)
H05B 33/08	(2006.01)
H01L 27/15	(2006.01)
H01L 33/00	(2010.01)

(52) **U.S. Cl.**

CPC ***H05B 33/08*** (2013.01); ***H01L 27/15*** (2013.01); ***H01L 33/0041*** (2013.01)

(58) **Field of Classification Search**

USPC .... 315/227 R, 237–238; 257/E29.344, 82, 257/84, 86, 68, 71, 13

See application file for complete search history.

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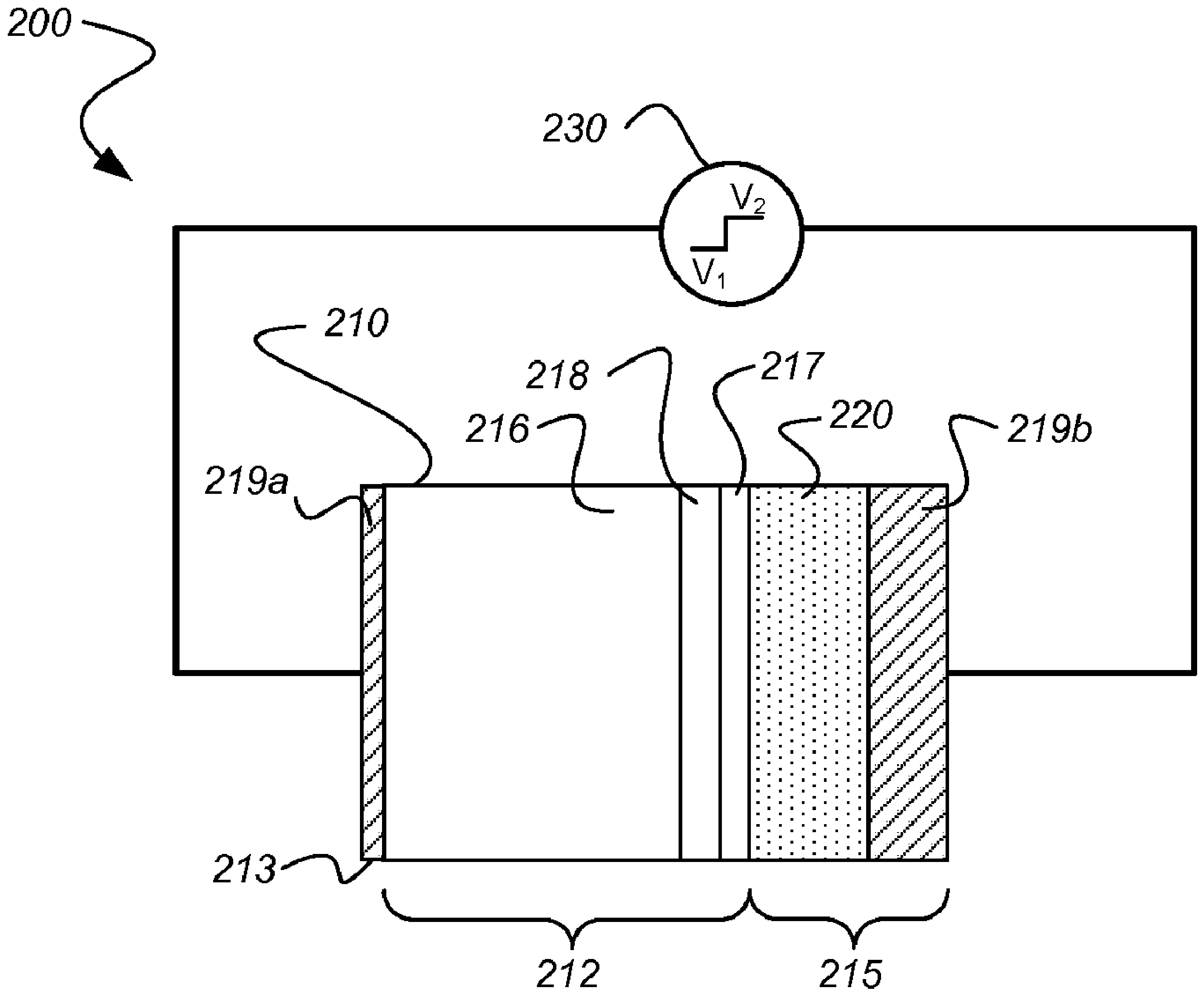
Primary Examiner — Minh D A

(74) *Attorney, Agent, or Firm* — Perkins Coie LLP

(57) **ABSTRACT**

Various embodiments of solid state transducer ("SST") devices are disclosed. In several embodiments, a light emitter device includes a metal-oxide-semiconductor (MOS) capacitor, an active region operably coupled to the MOS capacitor, and a bulk semiconductor material operably coupled to the active region. The active region can include at least one quantum well configured to store first charge carriers under a first bias. The bulk semiconductor material is arranged to provide second charge carriers to the active region under the second bias such that the active region emits UV light.

25 Claims, 10 Drawing Sheets



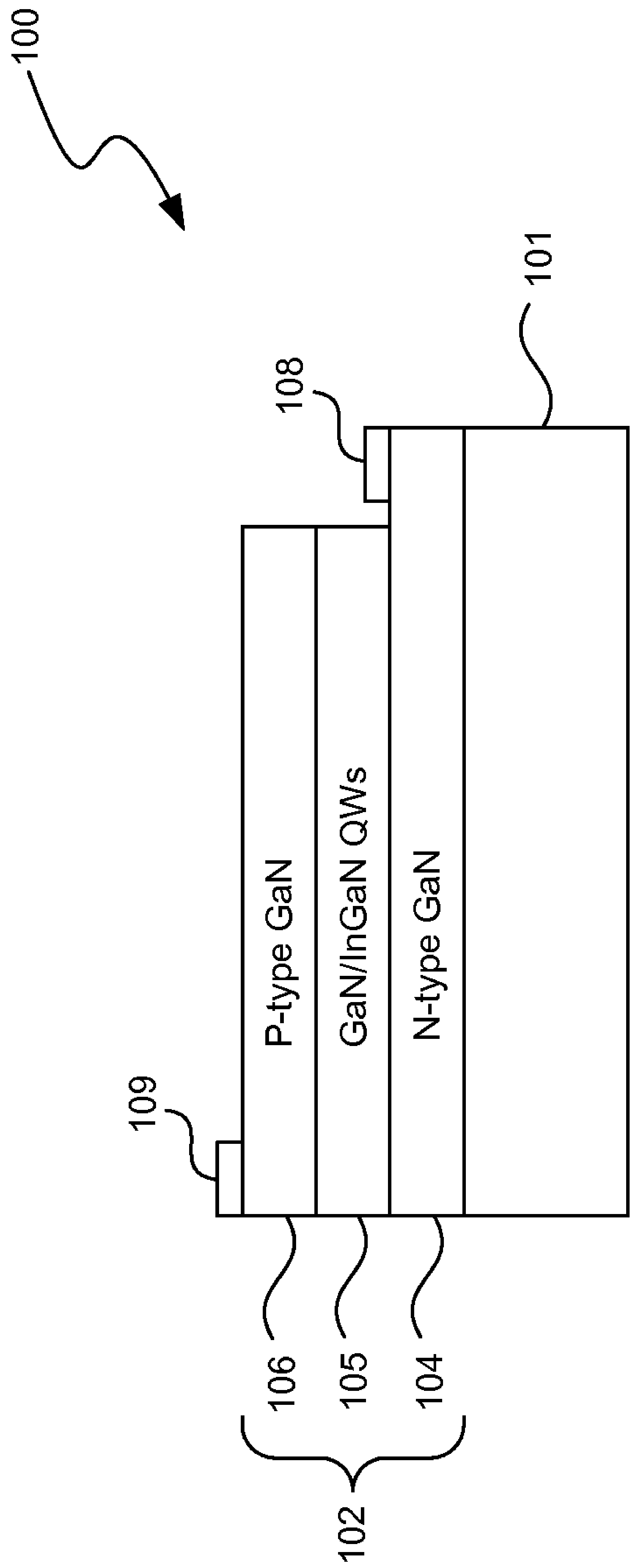


Fig. 1
(Prior Art)

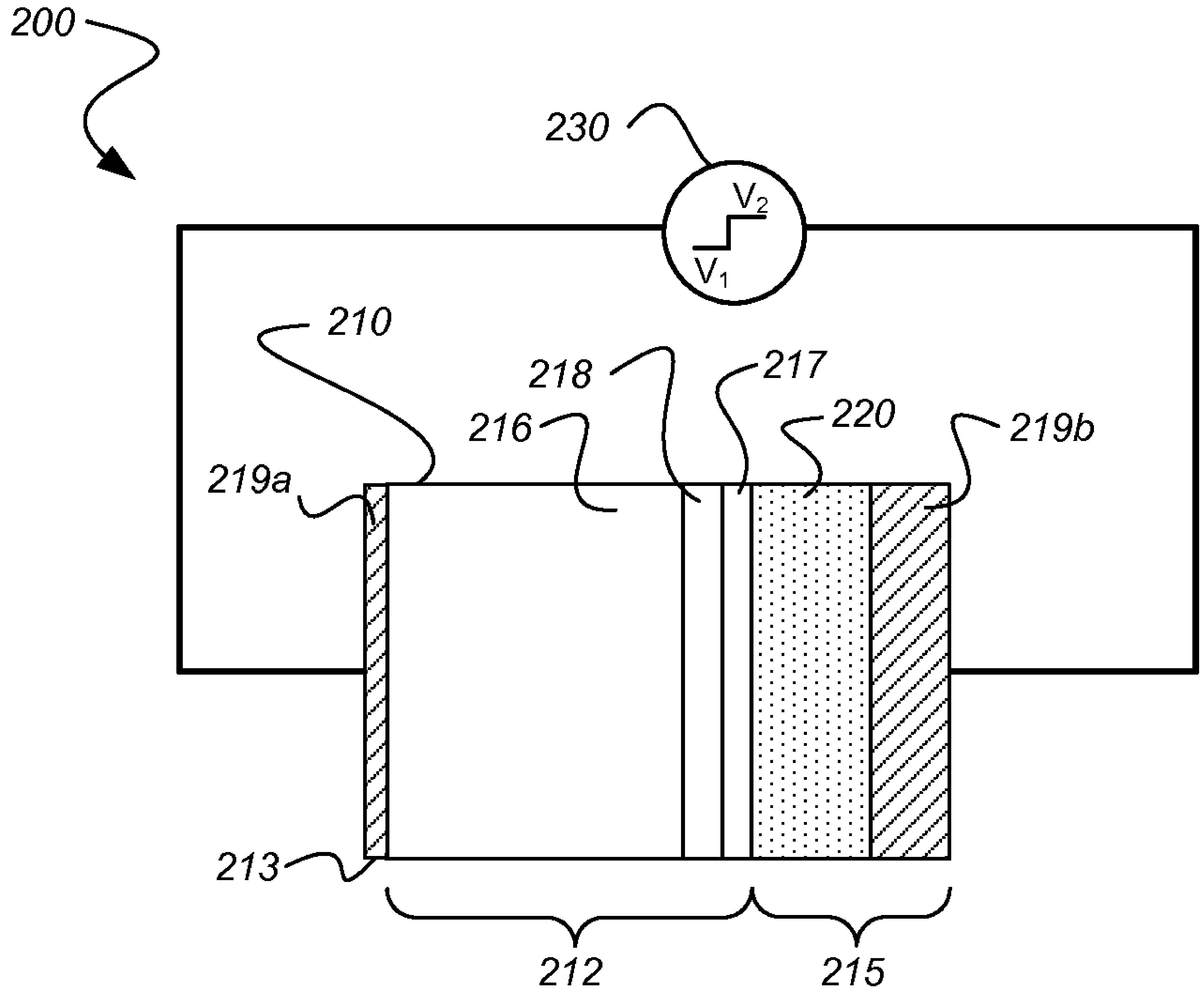


Fig. 2

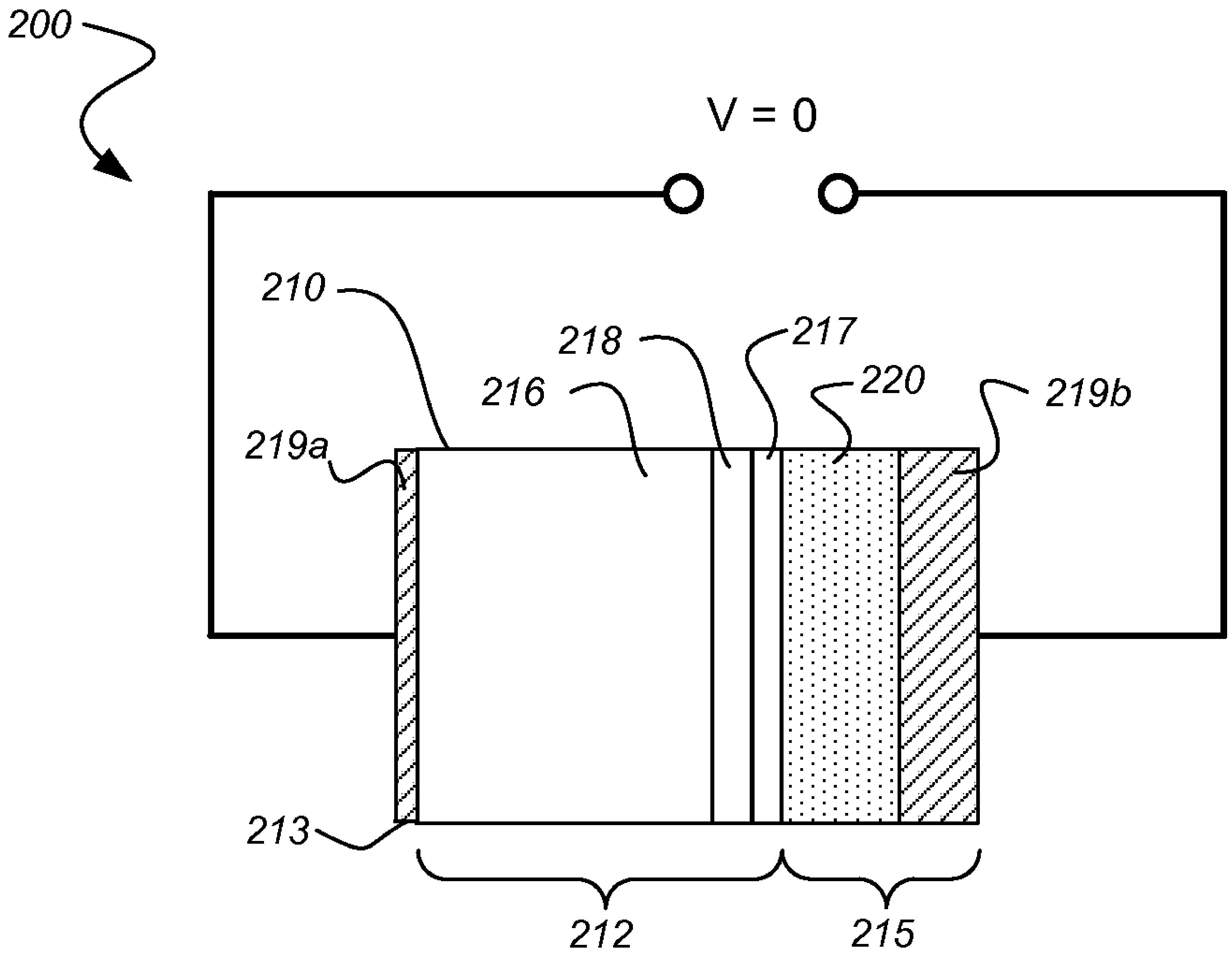

200
V = 0
210
218
217
216
220
219b
219a
213
212
215

Fig. 3A

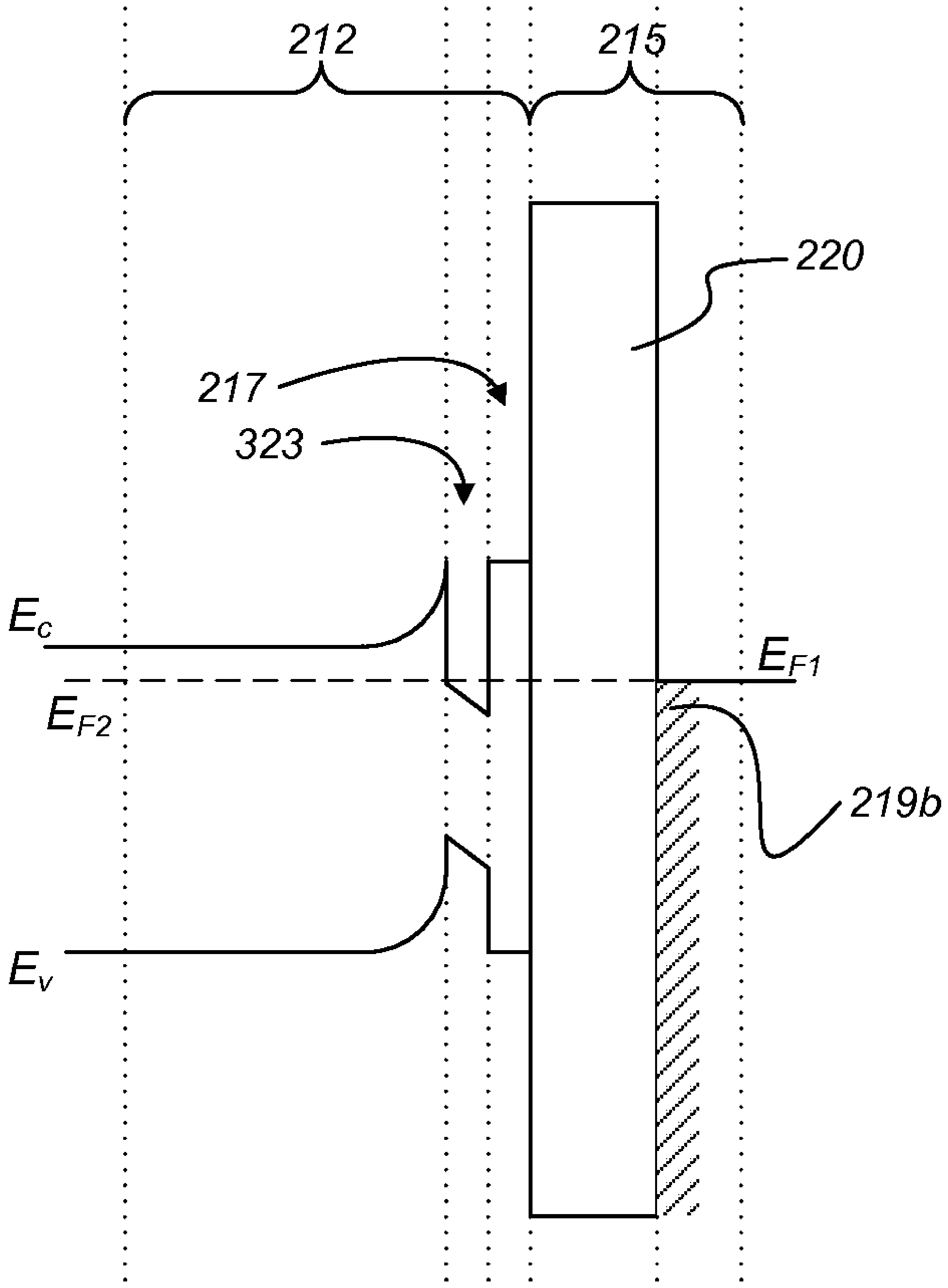

212
215
220
217
323
E_c
E_{F1}
E_{F2}
219b
E_v

Fig. 3B

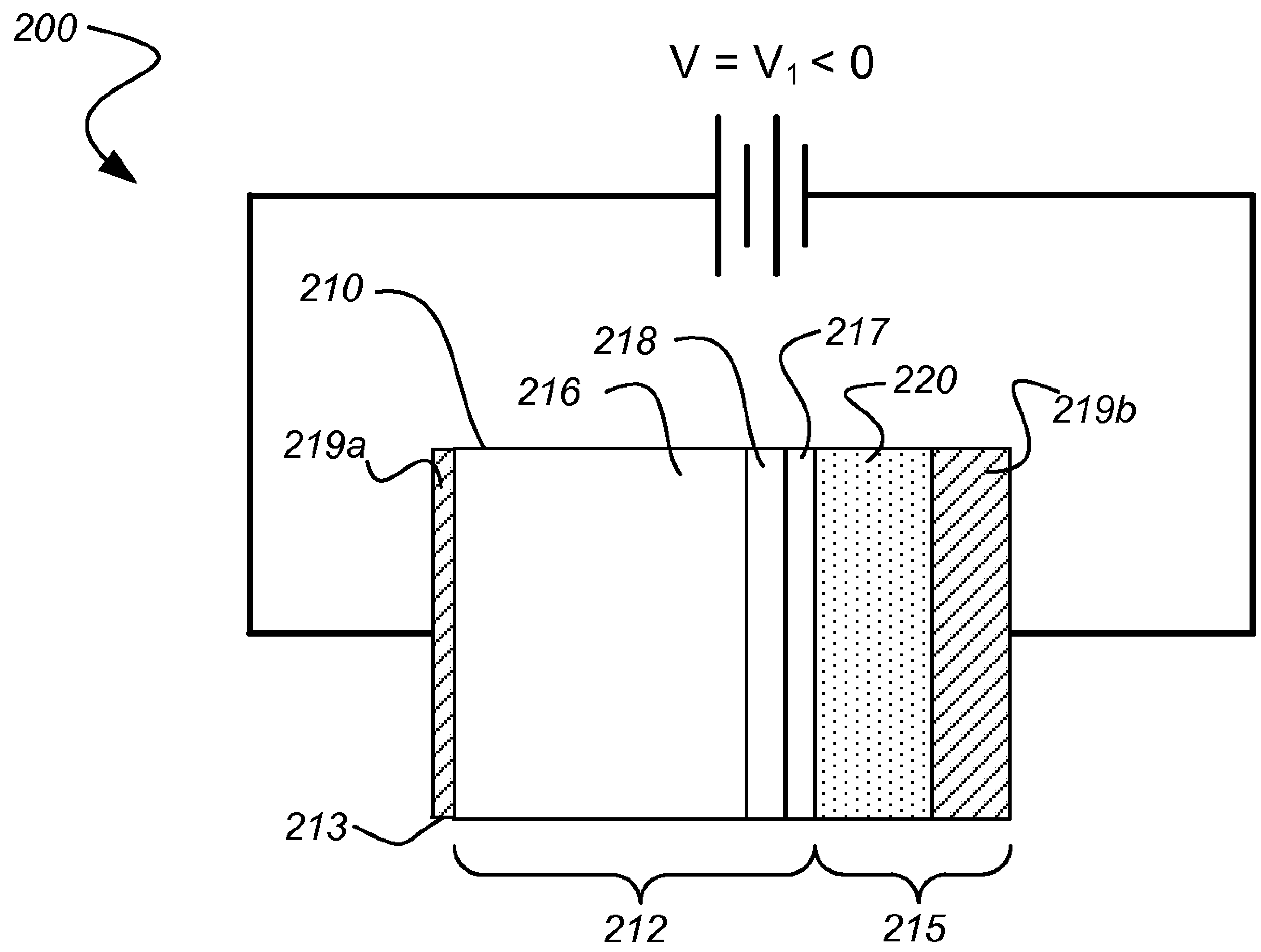

200
V = V1 < 0
210
218
217
216
220
219b
219a
213
212
215

Fig. 4A

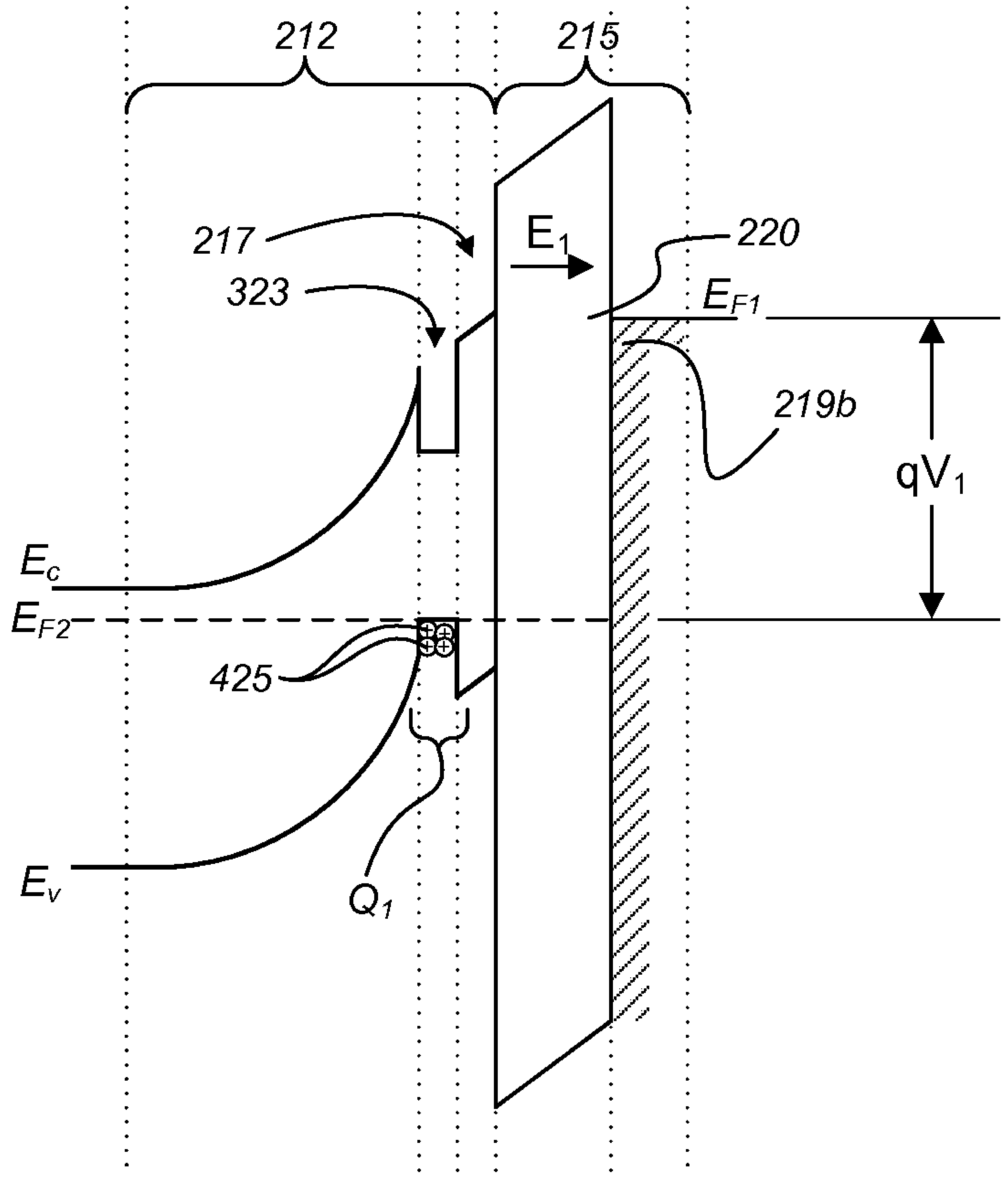

212
215
217
E1
220
323
EF1
219b
qV1
Ec
EF2
425
Ev
Q1

Fig. 4B

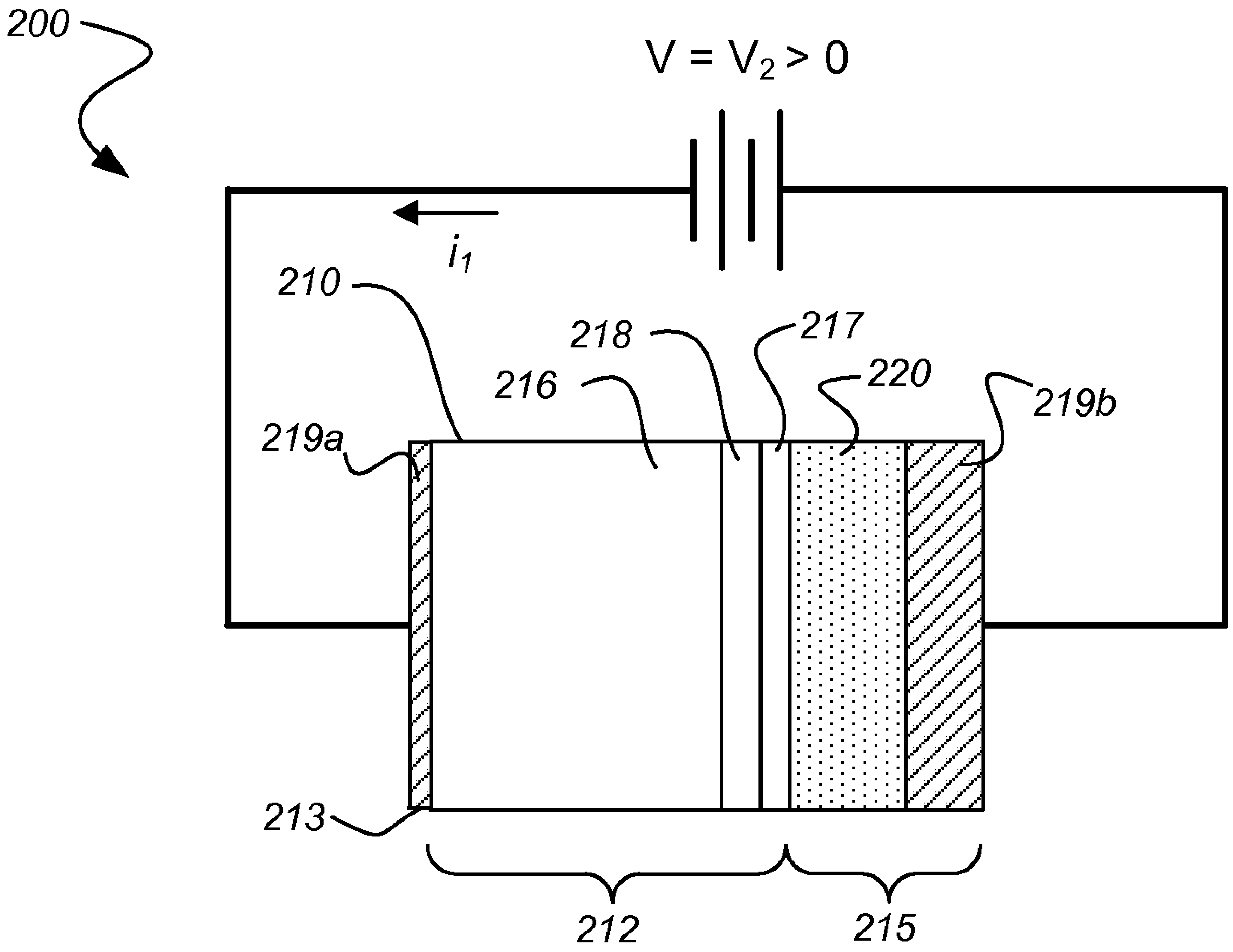

200
$V = V_2 > 0$
i_1
210
218
217
216
220
219b
219a
213
212
215

Fig. 5A

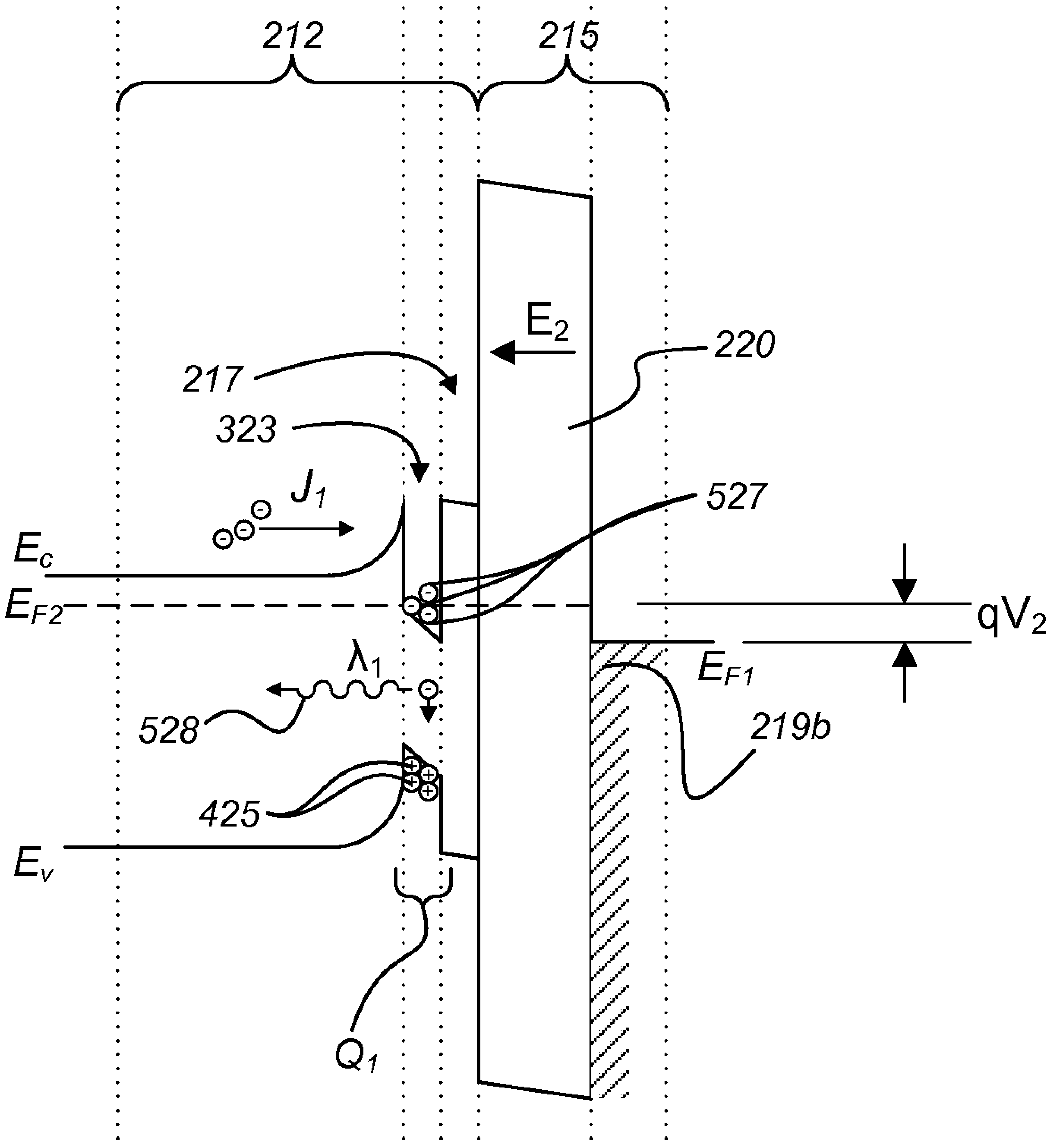

212
215
E_2
217
220
323
J_1
527
E_c
E_{F2}
qV_2
E_{F1}
λ_1
528
219b
425
E_v
Q_1

Fig. 5B

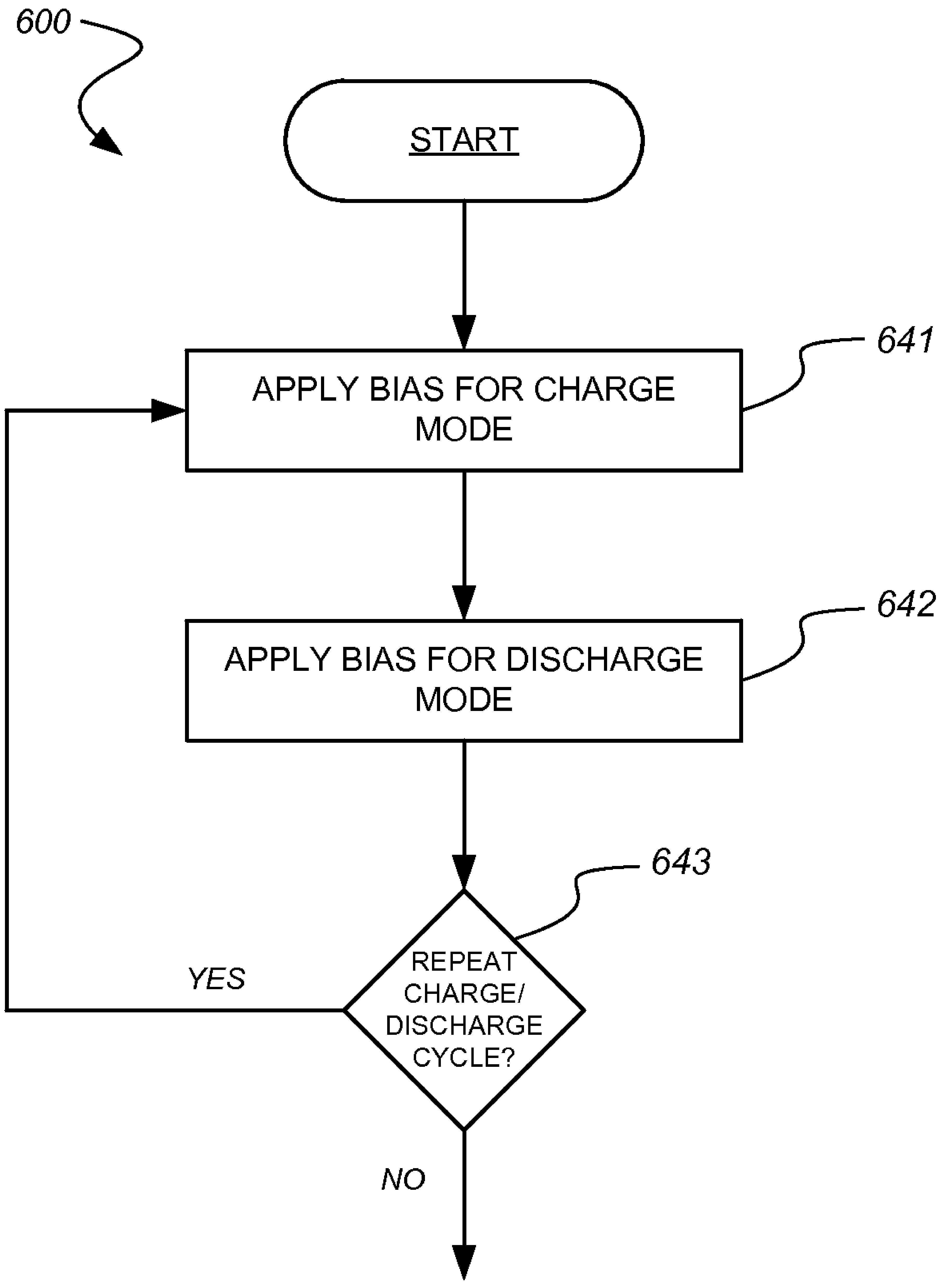

600
START
APPLY BIAS FOR CHARGE MODE
641
APPLY BIAS FOR DISCHARGE MODE
642
643
REPEAT CHARGE/ DISCHARGE CYCLE?
YES
NO

Fig. 6

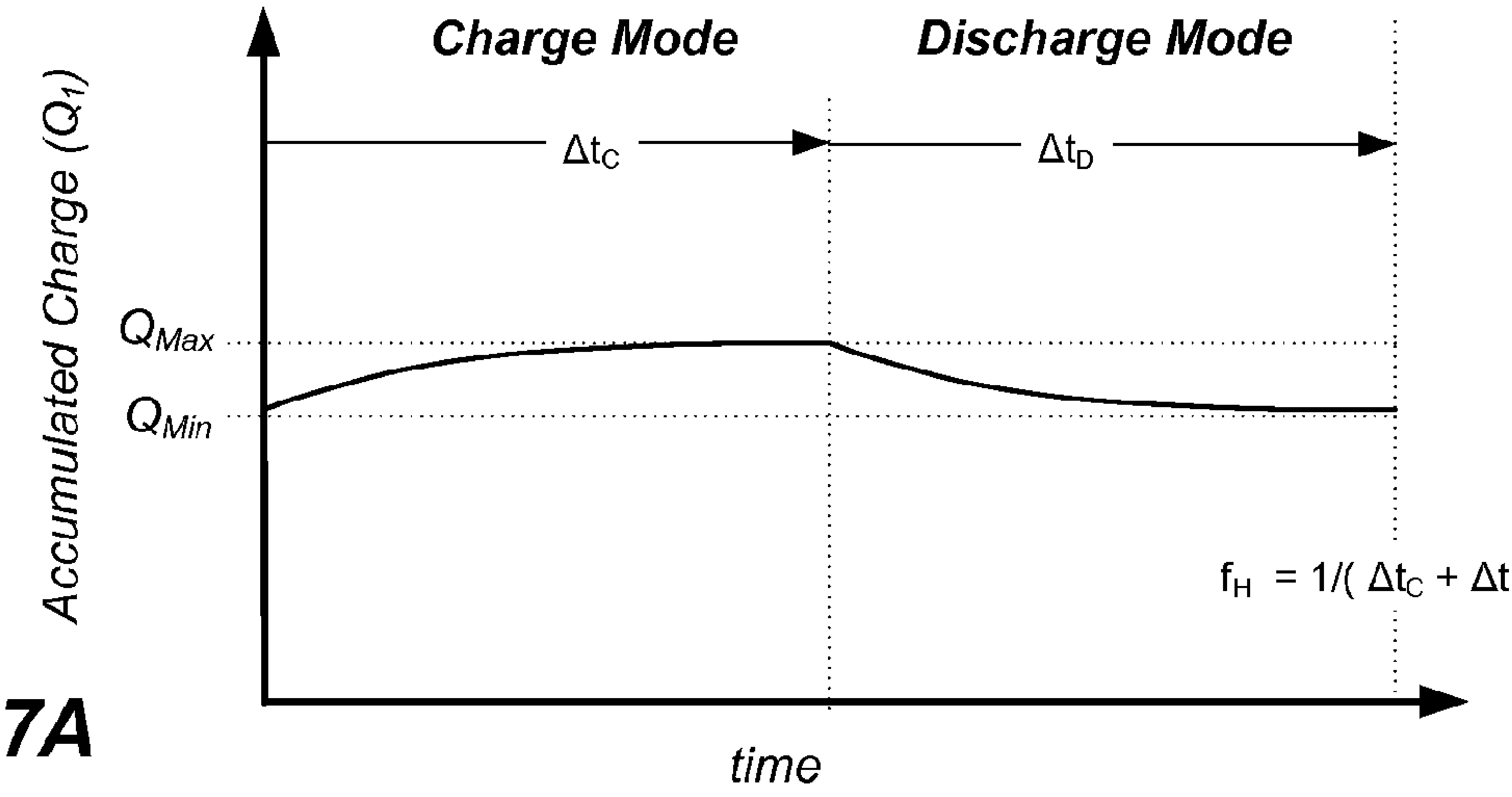


Fig. 7A

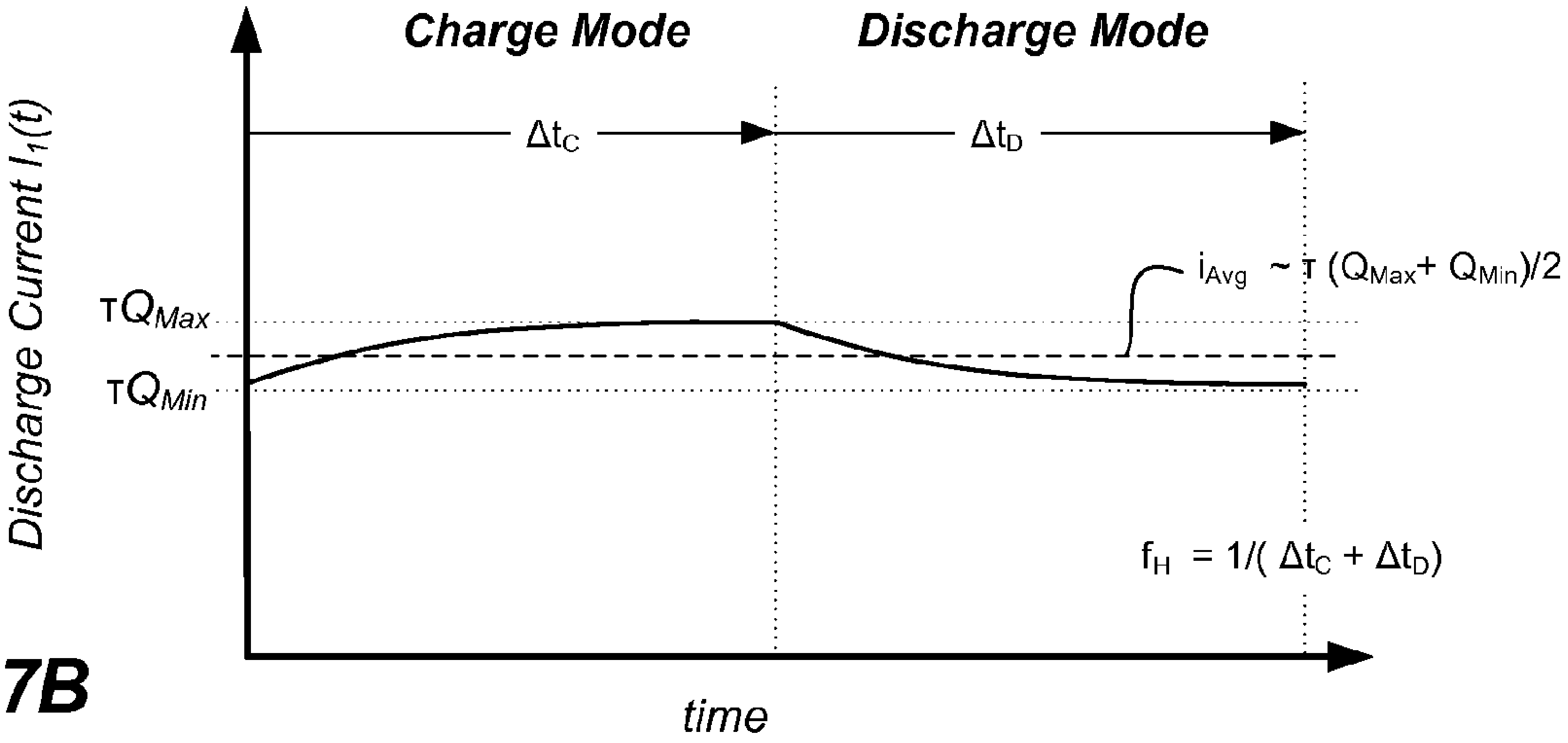


Fig. 7B

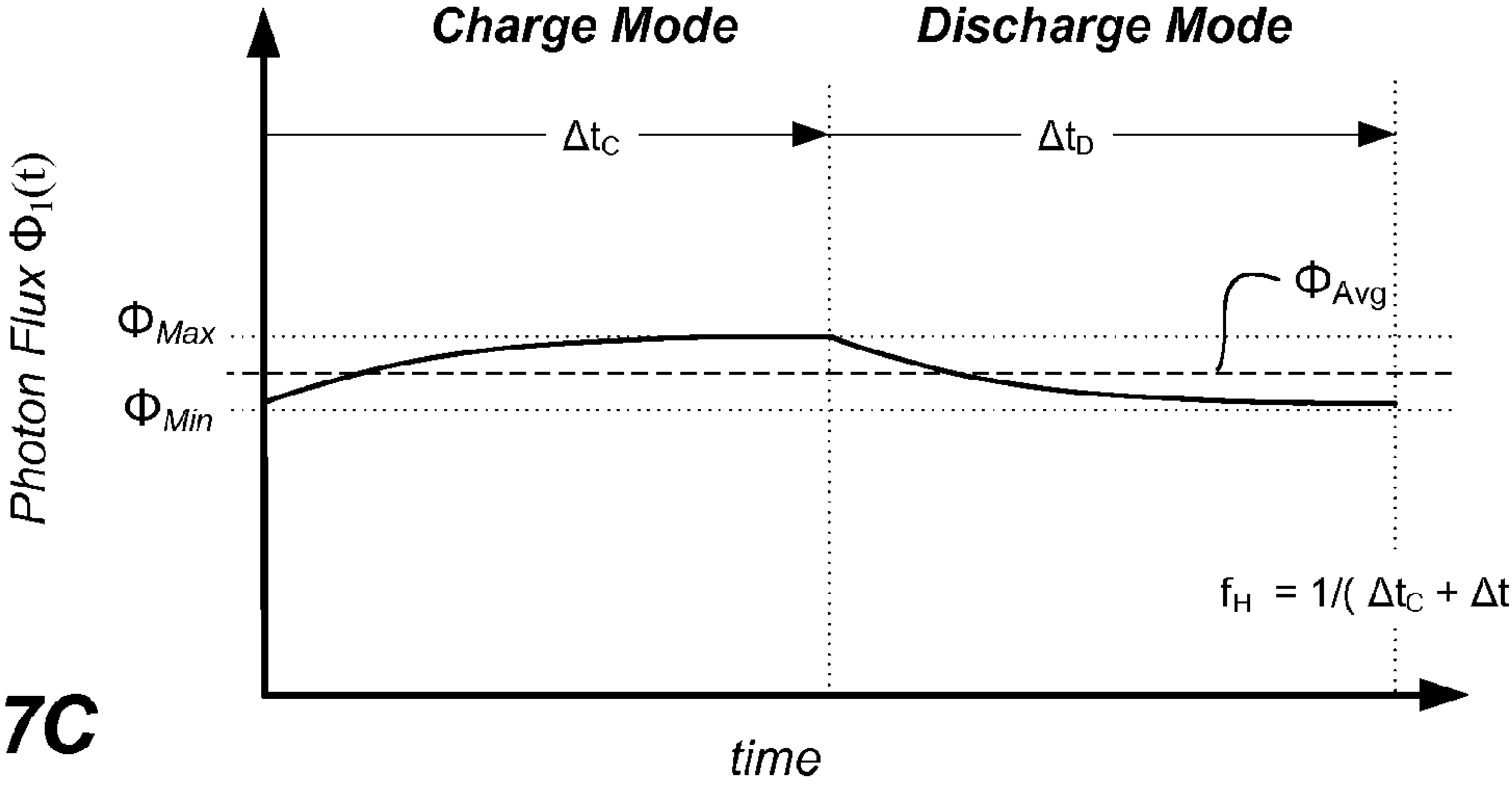


Fig. 7C

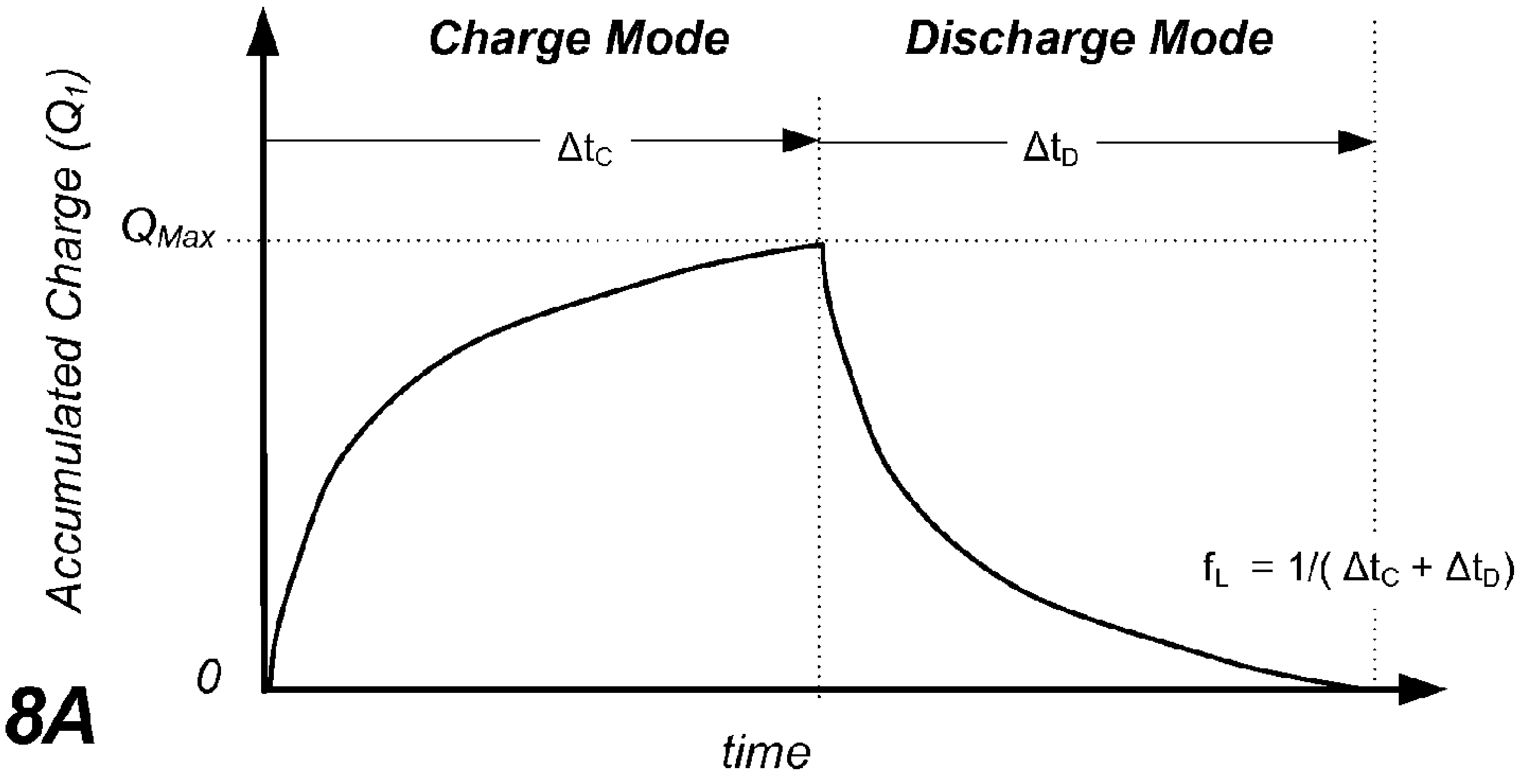


Fig. 8A

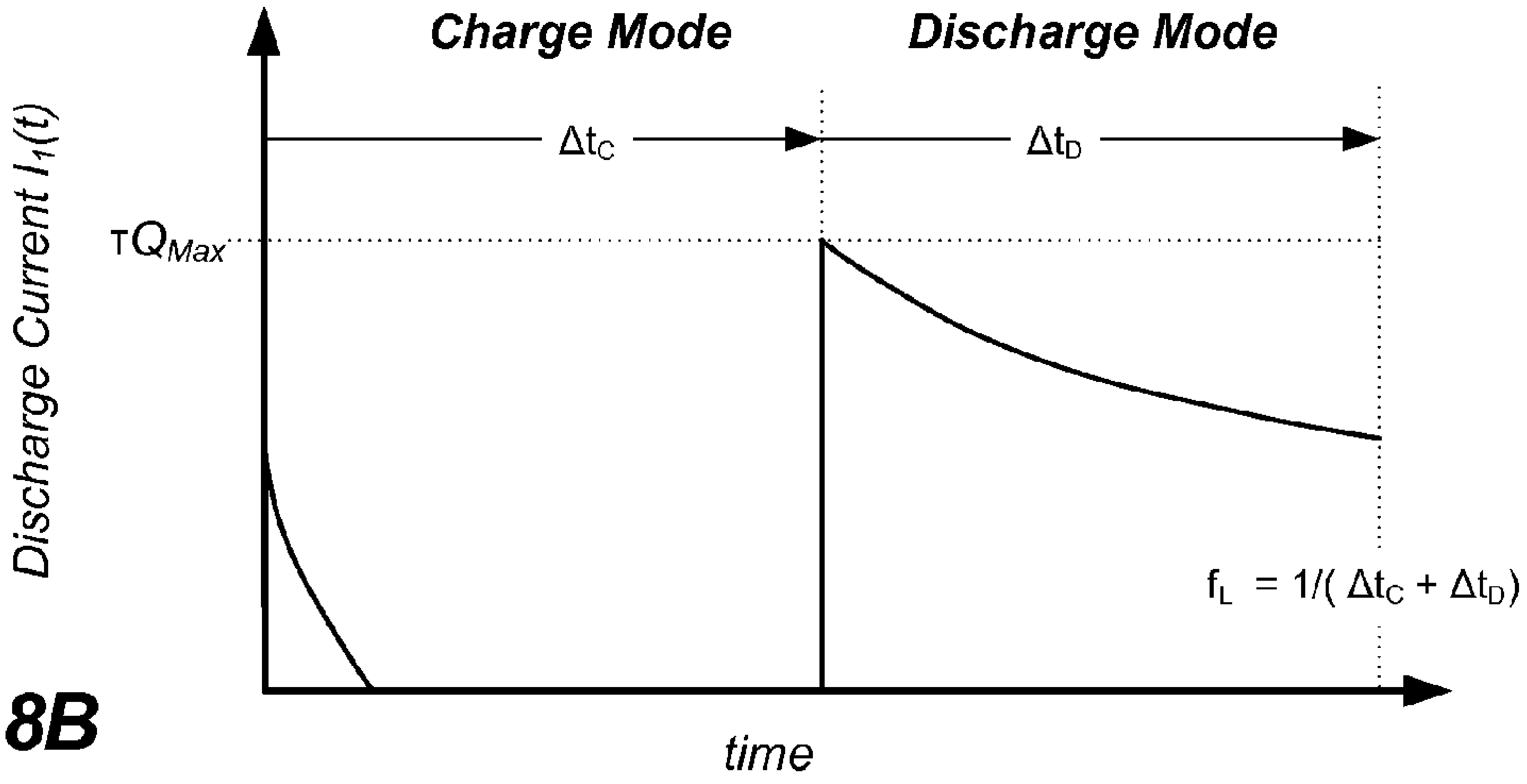


Fig. 8B

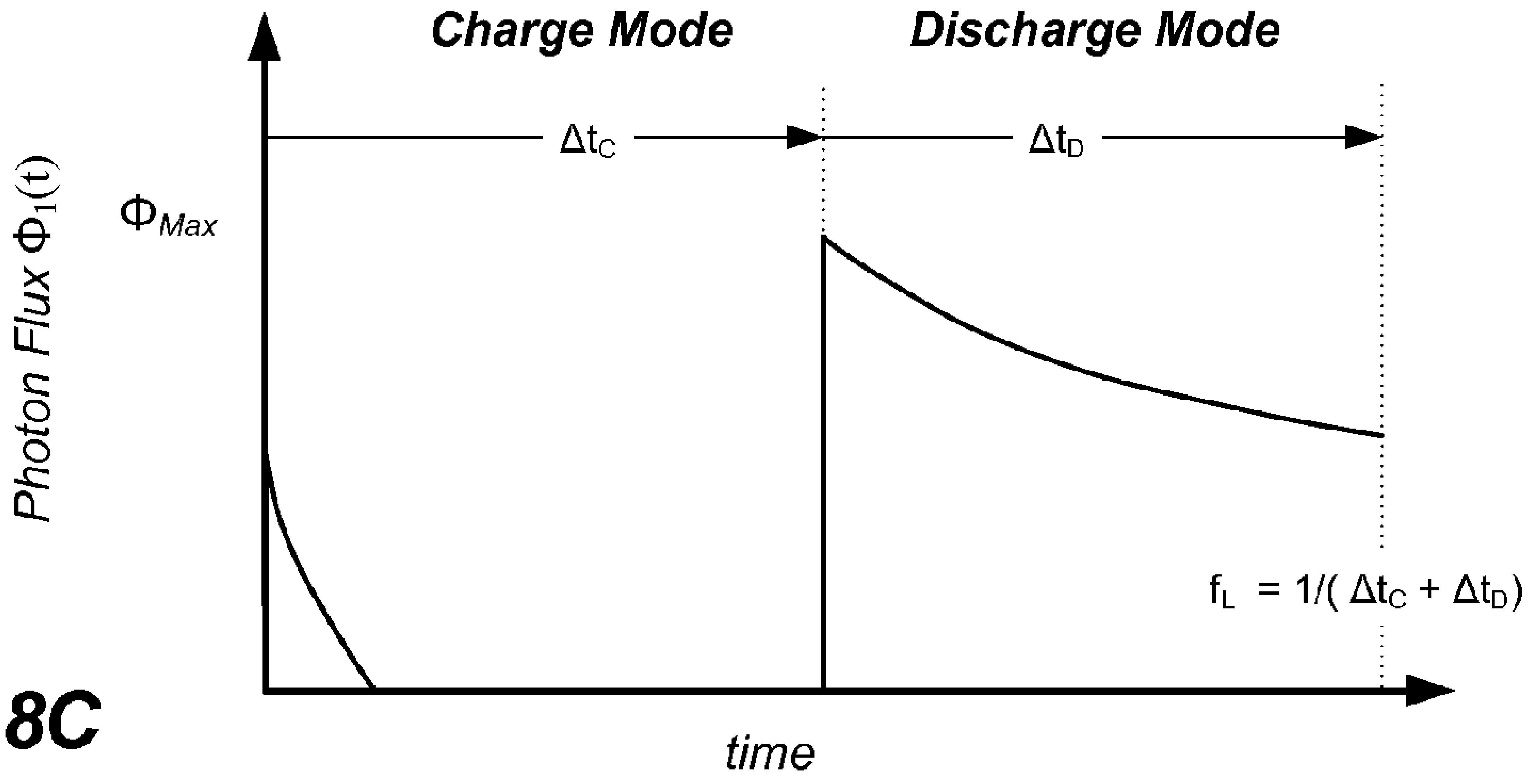


Fig. 8C

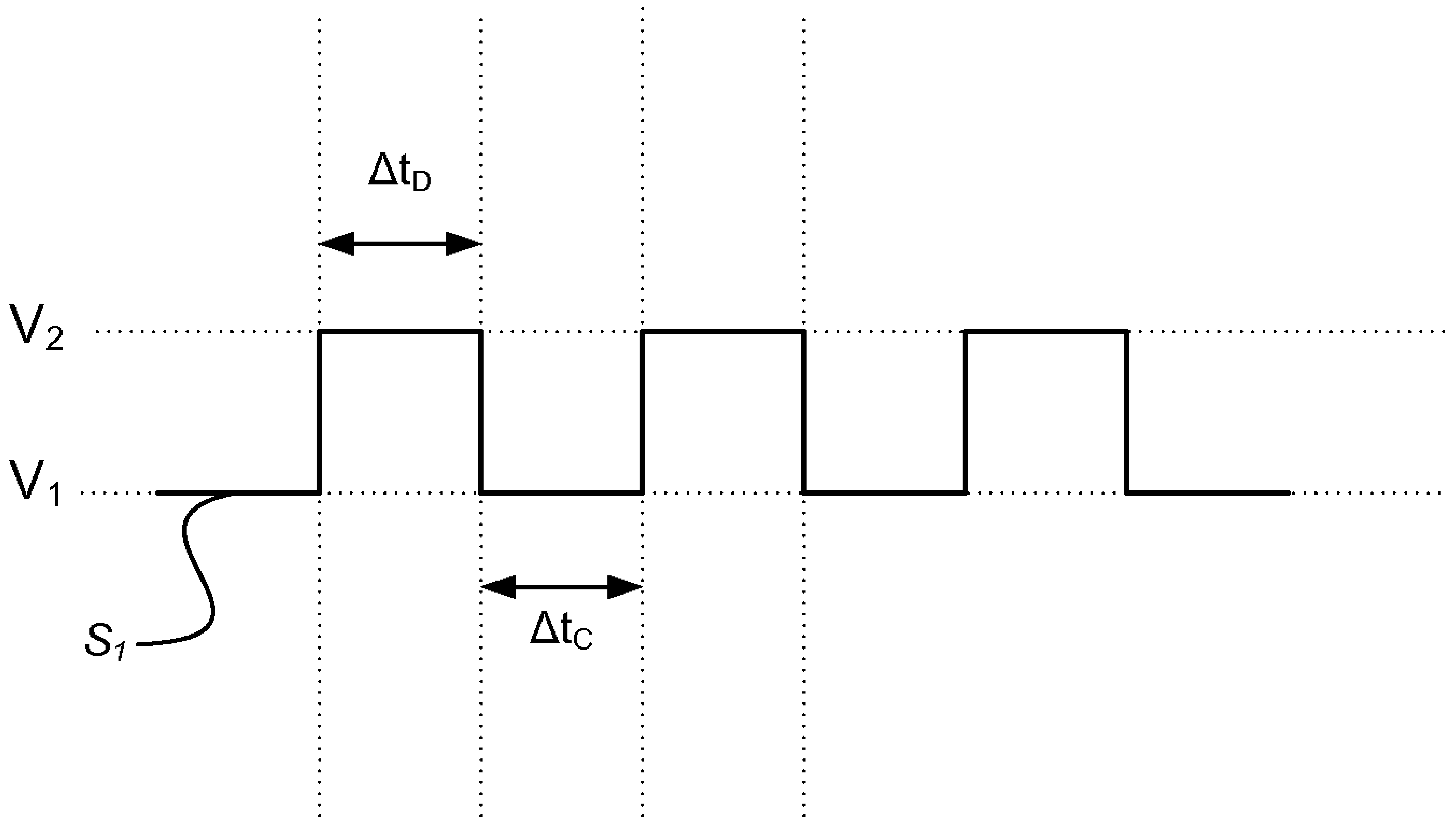


Fig. 9

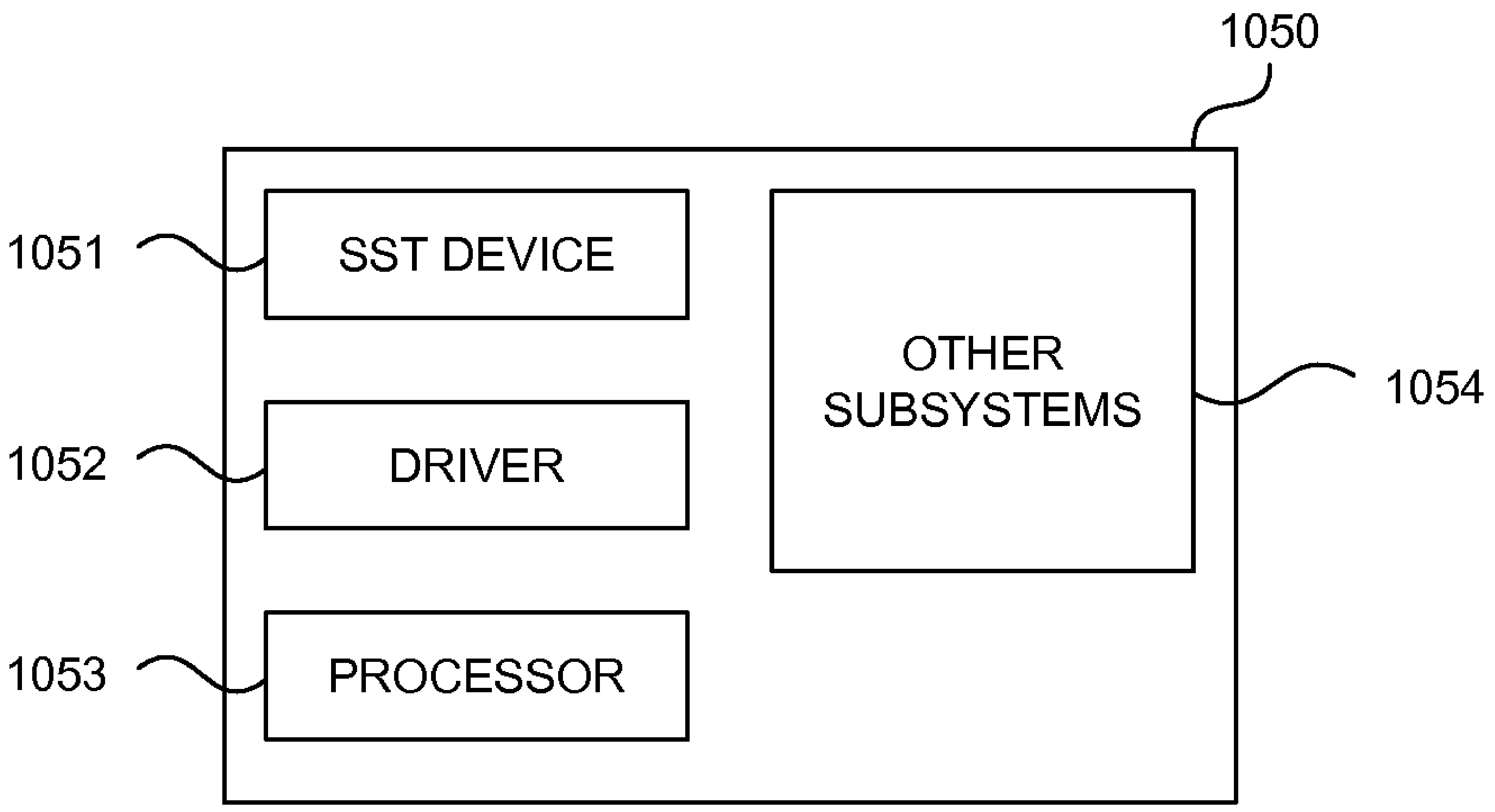

1050
1051
SST DEVICE
1052
DRIVER
1053
PROCESSOR
OTHER SUBSYSTEMS
1054

Fig. 10

LIGHT-EMITTING METAL-OXIDE-SEMICONDUCTOR DEVICES AND ASSOCIATED SYSTEMS, DEVICES, AND METHODS

TECHNICAL FIELD

The present disclosure is related to electrical contacts in light emitting semiconductor devices, such as light emitting diodes ("LEDs") and other solid state transducer ("SST") devices.

BACKGROUND

SST devices can have light emitting dies with different electrode configurations. For example, FIG. **1** is a cross-sectional view of a light emitting device **100**. As shown, the light emitting device **100** includes a substrate **101** carrying an LED structure **102** comprised of N-type gallium nitride (GaN) **104**, one or more GaN/indium gallium nitride (InGaN) quantum wells (QWs) **105**, and P-type GaN **106**. The light emitting device **100** also includes a first electrode **108** on the N-type GaN **104** and a second electrode **109** on the P-type GaN **106**. In operation, a voltage applied across the electrodes generates electron/hole pairs in the active regions of the LED structure **102**. When these pairs recombine, energy is released, including energy in the form of emitted light. In general, the wavelength of the emitted light is based on the energy difference between the electrons and holes before they recombine.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic cross-sectional view of a light emitting device configured in accordance with the prior art.

FIG. **2** is a schematic cross-sectional diagram of an SST system having a light emitter and a waveform generator configured in accordance with an embodiment of the present technology.

FIGS. **3**A and **3**B are a schematic cross-sectional diagram and an energy band diagram of the light emitter of FIG. **2** at equilibrium in accordance with an embodiment of the present technology.

FIGS. **4**A and **4**B are a schematic cross-sectional diagram and an energy band diagram of the light emitter of FIG. **2** under reverse bias in accordance with an embodiment of the present technology.

FIGS. **5**A and **5**B are a schematic cross-sectional diagram and an energy band diagram of the light emitter of FIG. **2** under forward bias in accordance with an embodiment of the present technology.

FIG. **6** is a flow diagram illustrating a method for operating the light emitter of FIG. **2** in accordance with an embodiment of the present technology.

FIGS. **7**A-**7**C show accumulated charge, discharge current, and photon flux, over a high frequency charge/discharge cycle of the light emitter of FIG. **2** in accordance with an embodiment of the present technology.

FIGS. **8**A-**8**C show charge accumulation, current discharge, and photon flux, over a low frequency charge/discharge cycle of the light emitter of FIG. **2** in accordance with an embodiment of the present technology.

FIG. **9** is a signal line diagram showing a bias signal configured to have a duty cycle for operating the light emitter of FIG. **2** in accordance with an embodiment of the present technology.

FIG. **10** is a schematic view of a system that includes a light emitter configured in accordance with selected embodiments of the present technology.

DETAILED DESCRIPTION

Various embodiments of light emitting devices, SST systems with light emitters, and associated methods are described below. As used hereinafter, the term "light emitter" generally refers to devices with one or more solid state light emitting devices, dies, and/or substrates, such as LEDs, laser diodes ("LDs"), and/or other suitable sources of illumination other than electrical filaments, a plasma, or a gas. A person skilled in the relevant art will also understand that the technology may have additional embodiments, and that the technology may be practiced without several of the details of the embodiments described below with reference to FIGS. **2**-**10**.

Conventional ultraviolet (UV) light emitters typically employ arrangements of GaN and aluminum GaN (AlGaN) materials. The AlGaN materials, in particular, can have alloyed/engineered concentrations of aluminum, N-type dopant, and P-type dopant to achieve a certain UV wavelength and/or spectrum of wavelengths. In operation, N-type and P-type AlGaN at least partially define a quantum well, with the P-type AlGaN configured to inject P-type charge carriers (i.e., holes) into the quantum well. One problem, however, with P-type AlGaN is that it has low conductivity and low light extraction efficiency. The conductivity is low because the acceptor species (e.g., magnesium (Mg)) has a high activation energy. The light extraction efficiency is low because P-type AlGaN is not compatible with the highly reflective materials ordinarily available for Ohmic connections in (non-UV) light emitters As a result, conventional UV light emitters can have operational efficiencies that are less than 5%. Embodiments of the present technology, however, address these and other limitations of conventional UV light emitters and other conventional emitters.

FIG. **2** is a schematic cross-sectional diagram of an SST system **200** having a light emitter **210** and a waveform generator **230** configured in accordance with an embodiment of the present technology. The light emitter **210** includes a semiconductor structure **212**, a first electrode **213**, and a second electrode **215**. The semiconductor structure **212** includes a bulk semiconductor material **216** ("bulk material **216**"), an optional spacer **217**, and an active region **218** between the bulk material **216** and the spacer **217**. The bulk material **216** can include, for example, a single grain semiconductor material (e.g., N-type AlGaN) with a thickness greater than about 10 nanometers and up to about 500 nanometers. The spacer **217** can include, for example, a single grain semiconductor material (e.g., GaN or AlGaN). The active region **218** can include a single quantum well ("SQW") or multiple quantum wells "MQWs." In one embodiment, the active region **218** includes a single grain semiconductor material (e.g., GaN or AlGaN) with a thickness in the range of about 1 nanometer to 10 nanometers. In another embodiment, the active region **218** includes a semiconductor stack of such materials.

The first electrode **213** includes a first conductive contact **219***a* connected to the bulk material **216**. The second electrode **215** includes a second conductive contact **219***b* and a dielectric material **220** between the second conductive contact **219***b* and the spacer **217**. The conductive contacts **219** can include, for example, a metal, a metal alloy, a doped silicon, and/or other electrically conductive substrate materials. The dielectric material **220** can include, for example, silicon oxide (SiO_2), silicon nitride (Si_3N_4), and/or other suitable non-conductive materials formed on the semiconductor structure **212** via thermal oxidation, chemical vapor deposition ("CVD"), atomic layer deposition ("ALD"), and/or other suitable techniques. In other embodiments, the dielectric material **220** can include a polymer (e.g., polytetrafluoroethylene and/or other fluoropolymer of tetrafluoroethylene), an epoxy, and/or other polymeric materials.

The waveform generator **230** is configured to output a bias signal. In the illustrated embodiments, the waveform generator **230** produces a square wave having a first voltage V_1 and a second voltage V_2. In other embodiments, however, the waveform generator **230** can output other types of waveforms having various pulse shapes, frequencies, voltages, current, power, etc. Because the basic structures and functions of waveform generators are known, they have not been shown or described in further detail to avoid unnecessarily obscuring the described embodiments.

In operation, the light emitter **210** functions similar to a capacitor (e.g., a metal-oxide-semiconductor (MOS) capacitor). The waveform generator **230** applies the first voltages V_1 to reverse bias the light emitter **210**, and it applies the second voltage V_2 to forward bias the light emitter **210**. As described in greater detail below, the reverse bias stores charge in the light emitter **210** and the forward bias releases the charge to emit light. In one embodiment, the light emitter **210** emits UV light (having wavelengths, e.g., in the range of 10 nm to 400 nm). In another embodiment, the light emitter **210** employs AlGaN materials, but not P-type AlGaN materials, to produce the UV light. As such, the light emitter **210** can have a larger conductivity and higher light extraction efficiency than conventional UV light emitters.

For purposes of clarity, only certain components of the SST system **200** have been shown in the illustrated embodiments. However, SST systems configured in accordance with various embodiments of the present technology can include other components. For example, in some embodiments the SST system **200** can include a lens, a mirror, and/or other suitable optical and/or electrical components.

FIGS. **3**A and **3**B are a schematic cross-sectional diagram and an energy band diagram of the light emitter **210** at equilibrium. Referring to FIGS. **3**A and **3**B together, the second conductive contact **219***b* has a first Fermi level E_{F1}. The semiconductor structure **212** includes a valence band E_v, a conduction band E_c, and a second Fermi level E_{F2} that is aligned with the first Fermi level E_{F1}. The semiconductor structure **212** also includes a quantum well **323** having available charge carrier (i.e., hole) energy states above the valence band E_v and available charge carrier (i.e., electron) energy states below the conduction band E_c. As shown, the valence and conduction bands E_v and E_c bend upwards at the left-hand side of the quantum well **323**, but they are generally flat within the region of the spacer **217**. In some embodiments, the spacer **217** can include an intrinsic or lightly N-type doped material to reduce or eliminate interfacial states (i.e., defect states) between the quantum well **323** and the dielectric material **220**. As such, the spacer **217** can directly contact the active region **218** (i.e., without a semiconductor material between the spacer **217** and the active region **218**. In other embodiments, however, the spacer **217** can be absent from the light emitter **210**.

FIGS. **4**A and **4**B are a schematic cross-sectional diagram and an energy band diagram of the light emitter **210** under reverse bias. Referring to FIGS. **4**A and **4**B together, the first voltage V_1 raises the first Fermi level E_{F1} above the second Fermi level E_{F2} to bring the active region **218** into inversion. As shown, the first voltage V_1 produces a first electric field E_1 across the dielectric material **220** that depletes electrons from the active region **218**. The electric field E_1 also draws holes **425** from the bulk material **216** into the active region **218**. The quantum well **323** traps the holes **425** and accumulates an electrical charge Q_1 ("accumulated charge Q_1"). In general, the accumulated charge Q_1 can be based on factors such as the magnitude of the first voltage V_1, a pulse width of the first voltage V_1, the number of quantum wells at the active region **218**, the resistivity of the semiconductor structure **212**, etc. As described in greater detail below, under a reverse bias, the accumulated charge Q_1 increases as a function of time to a maximum charge level Q_{Max}.

FIGS. **5**A and **5**B are a schematic cross-sectional diagram and an energy band diagram of the light emitter **210** under forward bias. Referring to FIGS. **5**A and **5**B together, the second voltage V_2 lowers the first Fermi level E_{F1} below the second Fermi level E_{F2} to bring the active region into accumulation. The second voltage V_2 produces a second electric field E_2 in the dielectric material **220** that draws electrons **527** from the bulk material **216** into the active region **218**. When the electrons **527** recombine with the holes **425** in the quantum well **323**, they emit light **528** (e.g., UV light). Also, the electrons **527** that flow through the bulk material **216** produce a discharge current i_1 that eventually depletes (e.g., partially or fully depletes) the accumulated charge Q_1. As described in greater detail below, under a forward bias, the accumulated charge Q_1 decreases as a function of time to a minimum charge level Q_{Min}.

FIG. **6** is a flow diagram illustrating a method **600** for operating the light emitter **210** in accordance with an embodiment of the present technology. In one aspect of the embodiment of FIG. **6**, the method **600** is a carried out by the waveform generator **230** (FIG. **2**). The method **600** begins after a start block. For example, the method **600** can start after powering on the SST system **200**. At block **641**, the waveform generator **230** charges the light emitter **210** in a "charge mode." In this mode, the waveform generator **230** can apply a first phase of a bias signal to the light emitter **210**. The first phase can include a first waveform that reverse biases the active region **218** (FIG. **2**). For example, a portion of the first waveform can have a signal level at the first voltage V_1. As described in greater detail below, the charge mode has an elapsed charge time Δt_C ("charge time Δt_C").

At block **642**, the waveform generator **230** discharges the light emitter **210** in a "discharge mode." In this mode, the waveform generator **230** can apply a second phase of the bias signal to the light emitter **210**. The second phase can include a second waveform that forward biases the active region **218**. For example, a portion of the second waveform can have a signal level at the second voltage V_2. As described in greater detail below, the discharge mode has an elapsed discharge time Δt_D ("discharge time Δt_D").

At decision block **643**, the waveform generator **230** completes a charge/discharge cycle, and it can return to block **641** to carry out another charge/discharge cycle. In several embodiments, the frequency of the charge/discharge cycle can be based on the charge time Δt_C and the discharge time Δt_D, as shown by Equation 1.

$$f_1 = 1/(\Delta t_C + \Delta t_D) \tag{1}$$

FIGS. **7**A-**7**C show accumulated charge (FIG. **7**A), discharge current (FIG. **7**B), and photon flux (FIG. **7**C) over a high frequency f_H charge/discharge cycle of the light emitter **210** in accordance with an embodiment of the present technology. Without being bound by theory, it is believed that the charge and discharge modes function in a manner somewhat analogous to a MOS capacitor. However, unlike a conventional MOS capacitor, the discharge mode also emits electromagnetic radiation (e.g., UV light) from the capacitor.

FIG. **7**A shows the accumulated charge Q_1 as a function of time over the high frequency f_H charge/discharge cycle. In charge mode, the accumulated charge Q_1 (t) increases from the minimum charge level Q_{Min} to the maximum charge level Q_{max} over the charge time Δt_C. In the discharge mode, the accumulated charge Q_1 (t) decreases from the maximum charge level Q_{Max} to the minimum charge level Q_{Min} over the discharge time Δt_D.

FIG. **7**B shows the discharge current $i_1(t)$ as a function of time over the high frequency f_H charge/discharge cycle. Without being bound by theory, it is believed that the discharge current $i_1(t)$ is proportional to the recombination rate τ of electron in the active region **218** (FIG. **2**). Also, because the cycle frequency is high, it is believed that in the charge mode, the electrons in the active region do not completely dissipate. Accordingly, for small differences in the maximum and minimum accumulated charge, the discharge current I_1 can be approximated, as shown by Equation 2.

$$I_{AVG}\sim\tau(Q_{Max}+Q_{Min})/2 \tag{2}$$

FIG. **7**C shows photon flux $\Phi_1(t)$ of emitted light (e.g., the light **528** of FIG. **5**) as a function of time over the high frequency f_H charge/discharge cycle. Without being bound by theory, it is believed that the average photon flux Φ_1 is proportional to the discharge current $I_1(t)$. Accordingly, based on Equation 2 the average photon flux Φ_1 can be approximated, as shown by Equation 3.

$$\Phi_{AVG}\propto\tau(Q_{Max}+Q_{Min})/2 \tag{3}$$

FIGS. **8**A-**8**C show accumulated charge (FIG. **8**A), discharge current (FIG. **8**B), and photon flux (FIG. **8**C) over a low frequency f_L charge/discharge cycle of the light emitter **210** in accordance with an embodiment of the present technology. In one respect, FIGS. **8**A-**8**C are different from FIGS. **7**A-**7**C in that Δt_C $(f_L)>\Delta t_C$ (f_H) and Δt_D $(f_L)>\Delta t_D$ (f_H).

FIG. **8**A shows the accumulated charge Q_1 as a function of time over the low frequency f_L charge/discharge cycle. In charge mode, the accumulated charge Q_1 (t) increases from zero charge to the maximum charge level Q_{Max} over the charge time Δt_C. In the discharge mode, the accumulated charge Q_1 (t) decreases from the maximum charge level Q_{Max} to zero charge over the discharge charge time Δt_D. Without being bound by theory (and similar to high/low frequency behavior of a MOS capacitor), it is believed that the maximum accumulated charge at low frequency Q_{Max} (f_L) is greater than the maximum accumulated charge at high frequency Q_{Max} (f_H).

FIG. **8**B shows the discharge current $i_1(t)$ as a function of time over the low frequency f_L charge/discharge cycle. Without being bound by theory, it is believed that because the cycle frequency f_L is low frequency, the electrons in the active region dissipate during charge mode. As such, the discharge current $i_1(t)$ ceases to flow over the majority of the charge time Δt_C. Similar to FIG. **7**B, it is believed that during the discharge mode, current $i_1(t)$ is proportional to the recombination rate τ of electron in the active region **218** (FIG. **2**).

FIG. **8**C shows photon flux $\Phi_1(t)$ of emitted light (e.g., the light **528** of FIG. **5**) as a function of time over the low frequency f_L charge/discharge cycle. Without being bound by theory, it is believed that the maximum photon flux at low frequency Φ_{MAX} (f_L) is greater than the maximum photon flux at high frequency Φ_{MAX} (f_H). In particular, it is believed that this is due to larger amount of accumulated charge at the low frequency charge mode (FIG. **8**A). In some embodiments, it is believed that the low cycling frequency f_L can emit pulsed light. For example, during the charge mode, the discharge current can reduce to zero, such that the light emitter **210** does not output photons for a portion of the charge time Δt_C. Accordingly, by appropriate selection of the duty cycle, it is believed that emitted light can be shaped to have variously pulses widths.

FIG. **9** is a signal line diagram showing a bias signal S_1 configured to have a duty cycle for operating the light emitter **210** in accordance with an embodiment of the present technology. The charge mode of the bias signal S_1 has a charge-mode duty cycle that can be represented by Equation 4 and a discharge-mode duty cycle that can be represented by Equation 5.

$$\text{Duty Cycle(Charge mode)}=\Delta t_C/(\Delta t_C+\Delta t_D) \tag{4}$$

$$\text{Duty Cycle(Discharge mode)}=\Delta t_D/(\Delta t_C+\Delta t_D) \tag{5}$$

In the illustrated embodiments, the duty cycle of the charge and discharge modes is 50%. In other embodiments, however, the duty cycle can be configured differently. For example, if the recombination rate τ limits the rate of discharge, the duty cycle of the charge mode can be reduced (e.g., to 25%) to reduce the charge time. As such, the duty cycled of the discharge mode will increase (e.g., to 75%) to allow more time for discharge. In one embodiment, the duty cycle can be selected to provide pulsed light. In another embodiment, the duty cycle can be selected to provide non-pulsed light. In certain embodiments, the bias signal S_1 can be configured to have other features, such as leading and/or falling edges that are sloped, a time-varying duty cycle, multiple voltage levels, sinusoidal waveforms, etc. For example, the bias signal S_1 can include a first phase to initially charge (e.g., ramp up) the light emitter **210** and a second phase to operate the light emitter **210** at steady state (i.e., a steady state of pulsed light or non-pulsed light).

The light emitter **210** and/or the SST system **200** described above with reference to FIGS. **2**-**9** can be used to form SST devices, SST structures, and/or other semiconductor structures that are incorporated into any of a myriad of larger and/or more complex devices or systems, a representative example of which is system **1050** shown schematically in FIG. **10**. The system **1050** can include one or more semiconductor/SST devices **1051**, a driver **1052**, a processor **1053**, and/or other subsystems or components **1054**. The resulting system **1050** can perform any of a wide variety of functions, such as backlighting, general illumination, power generations, sensors, and/or other suitable functions. Accordingly, representative systems can include, without limitation, hand-held devices (e.g., mobile phones, tablets, digital readers, and digital audio players), lasers, photovoltaic cells, remote controls, computers, and appliances. Components of the system **1050** may be housed in a single unit or distributed over multiple, interconnected units (e.g., through a communications network). The components of the system **1050** can also include local and/or remote memory storage devices, and any of a wide variety of computer readable media.

From the foregoing, it will be appreciated that specific embodiments of the disclosure have been described herein for purposes of illustration, but that various modifications may be made without deviating from the disclosure. For example, in some embodiments, the maximum and/or minimum accumulated charge can be configured based on material properties, in addition to or in lieu of the cycle frequency and/or the bias level. These material properties can include, for example, conductivity, carrier mobility, carrier effective mass, impurity concentration, etc. Also, the various waveforms shown in the Figures can have different slopes, magnitudes, shapes, etc. Similarly, the semiconductor devices, substrates, and other features can have shapes, sizes, and/or other characteristics different than those shown and described with reference to the Figures. For example, the conductive contacts **219** of the light emitter **210** can have different configurations (e.g., lateral or vertical configurations). In addition, certain aspects of the disclosure described in the context of particular embodiments may be combined or eliminated in other embodiments. Further, while advantages associated with certain embodiments have been described in the context of those embodiments, other embodiments may also exhibit such advantages. Not all embodiments need necessarily exhibit such advantages to fall within the scope of the present disclosure. For example, in some embodiments, light emitters can be configured to work with P-type materials. Accordingly, the disclosure and associated technology can encompass other embodiments not expressly shown or described herein.

We claim:

1. A solid state transducer (SST) system, comprising:

a light emitter device including a capacitor, a conductive contact, and an active region between the capacitor and the conductive contact; and

a waveform generator having a first terminal operably coupled to the capacitor and a second terminal operably coupled to the conductive contact, wherein the waveform generator is configured to generate a bias signal that alternatingly charges and discharges the capacitor to emit electromagnetic radiation from the active region.

2. The SST system of claim **1** wherein the capacitor includes a metal-oxide-semiconductor (MOS) capacitor.

3. The SST system of claim **1** wherein the electromagnetic radiation is in the ultraviolet (UV) spectrum.

4. The SST system of claim **1** wherein the light emitter device further includes a spacer between the active region and the capacitor region without a semiconductor material between the spacer and the active region.

5. The SST system of claim **1** wherein the bias signal includes a first waveform configured to accumulate charge in the capacitor and a second waveform configured to draw a current that at least partially discharges the accumulated charge.

6. The SST system of claim **1** wherein the bias signal has a charge/discharge cycle based on a charge time and a discharge time of the capacitor, wherein a duty cycle of the charge time and the discharge time is configured such that the active region outputs the electromagnetic radiation throughout charge/discharge cycle.

7. The SST system of claim **1** wherein the bias signal has a charge/discharge cycle based on a charge time and a discharge time of the capacitor, wherein a duty cycle of the charge time and the discharge time is configured such that the active region does not emit the electromagnetic radiation for a portion of the charge/discharge cycle.

8. The SST system of claim **1** wherein the bias signal has a frequency configured such that the electromagnetic radiation is pulsed.

9. The SST system of claim **1** wherein the bias signal has a frequency configured such that the electromagnetic radiation is generally non-pulsed.

10. A method for operating a light emitter device having a capacitor, a conductive contract, and an active region between the capacitor and the conductive contact, the method comprising:

generating a bias signal using a waveform generator, the waveform generator having a first terminal operably coupled to the capacitor, and a second terminal operably coupled to the conductive contact, and

alternatively charging and discharging the capacitor with the bias signal generated by the waveform generator to emit electromagnetic radiation from the active region.

11. The method of claim **10** wherein charging the capacitor includes charging the capacitor with a bias signal, wherein a duty cycle of the bias signal is configured such that the capacitor emits a portion of the electromagnetic radiation while the capacitor is charging.

12. The method of claim **10** wherein a duty cycle of the bias signal is configured to pulse the electromagnetic radiation.

13. The method of claim **10** wherein the capacitor includes a metal-oxide-semiconductor (MOS) capacitor and the active region includes at least one quantum well operably coupled to the MOS capacitor to emit the electromagnetic radiation.

14. The method of claim **10** wherein the electromagnetic radiation is in the ultraviolet (UV) spectrum.

15. The method of claim **10** wherein alternatingly charging and discharging the capacitor with the bias signal includes alternatingly cycling the bias signal between at least a first voltage and at least a second voltage different than the first voltage.

16. The method of claim **10** wherein alternatingly charging and discharging the capacitor with the bias signal further includes:

applying the first voltage for a first duration of time to charge the capacitor; and

applying the second voltage for a second duration of time to discharge the capacitor.

17. The method of claim **16** wherein alternatingly charging and discharging the capacitor with the bias signal further includes applying the second voltage for a duration of time to discharge the capacitor.

18. A solid state transducer (SST) system, comprising:

a waveform generator having a first terminal and a second terminal, wherein the waveform generator is configured to apply a bias signal across the first and second terminals; and

a light emitter device having an active region, a conductive contact between active region and the first terminal, and a capacitor between the active region and the second terminal,

wherein the waveform generator is configured to alternatingly charge and discharge the capacitor via the applied biased signal to emit electromagnetic radiation from the active region.

19. The SST system of claim **18** wherein the capacitor comprises a metal-oxide-semiconductor (MOS) capacitor and the active region includes at least one quantum well.

20. The SST system of claim **18**, further comprising a bulk semiconductor material between the conductive contact and the capacitor.

21. The SST system of claim **20** wherein:

the active region includes at least one of gallium nitride (GaN) or aluminum GaN (AlGaN); and

the bulk semiconductor material includes N-type AlGaN, wherein the active region and the bulk semiconductor material do not include P-type GaN nor P-type AlGaN.

22. The SST system of claim **18**, further comprising a spacer material between the capacitor and the active region.

23. The SST system of claim **22** wherein the active region directly contacts the spacer.

24. The SST system of claim **18**, further comprising a bulk semiconductor material and a spacer, wherein the active region is between the bulk semiconductor material and the active region.

25. The SST system of claim **24** wherein the spacer material includes at least one of gallium nitride (GaN) or aluminum GaN (AlGaN), but not P-type GaN nor P-type AlGaN.

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